

**INFLUENCE OF GEOCHEMICAL PROCESSES ON NUTRIENT SPIRALING WITHIN  
THE RECIRCULATION ZONES OF THE COLORADO RIVER IN THE GRAND  
CANYON**

**QUARTERLY REPORT: 1 October, 1994**

Roderic A. Parnell, Jeffery B. Bennett,  
Geology Department  
Northern Arizona University, Campus Box 4099  
Flagstaff, AZ 86011

Cooperative Agreement: CA8000-8-0002

Project Name: **Influence of Geochemical Processes on Nutrient Spiraling Within the Recirculation Zones of the Colorado River in the Grand Canyon**

Principal Investigator: Dr. Roderic A. Parnell

Government Technical Representative: Dr. Peter Rowlands

Title of Work: **BEACH GEOCHEMISTRY AND NUTRIENT SPIRALING:**  
**Quarterly report**

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## BEACH GEOCHEMISTRY AND NUTRIENT SPIRALING ANNUAL REPORT: 1993

### A. MAJOR ACCOMPLISHMENTS

#### 1. Overview of Project

The Bureau of Reclamation is the lead agency charged with preparing an Environmental Impact Statement on the impacts of Glen Canyon Dam operations on resources downstream in Glen and Grand Canyons. Implementation of Interim Flow criteria for Glen Canyon Dam during the EIS preparation period requires that sand bar conditions be monitored to assess how linkages between sediment resources and channel flow been affected by this action. The present research is a monitoring study designed to determine the influence of fluctuating flows on biogeochemical reactions occurring within the recirculation deposits, specifically the reattachment bar. This project is being conducted through the National Park Service Cooperative Parks Studies Unit at Northern Arizona University in Flagstaff

#### 2. Objectives

- A. Describe and interpret the redox chemistry, especially with respect to nitrogen species, within the alluvial deposits of the recirculation zones.
- B. Document the changes in water chemistry as waters flow through the alluvium.
- C. Construct a geochemical model providing insight into the relationship between geochemical processes within the alluvial deposits and the biogeochemistry of the main stem.

#### 3. Accomplishments

We have completed four trips to three of our sites and three trips to our fourth. On our first trip, 49 wells were installed and sampled on three reattachment bars; 43.1L, 71.1L and 194L. Wells were clustered in pairs with a shallow well at approximately three meters and a deeper well at a depth of approximately six meters. Wells were placed in coarse sand units to avoid well screen clogging problems associated with fine-grained units. Samples were collected and field measurements were made at least 24 hours after installation. These sites were visited and sampled again in July, October, and January. When available, return channel samples and at least two eddy samples were taken when wells were sampled. On our second trip (July, 1993) we added two field measurements; dissolved oxygen (DO) and ammonium concentrations. Our initial DO measurements were done with a DO probe, however we are now titrating in the field (modified Winkler method). On the October trip, we had the opportunity to sample several wells at different river stage levels. In June we went to -6 mile and installed 12 wells. This site was sampled in November 1993, April 1994 and July 1994. Laboratory analysis of the all the samples is near completion and the data is compiled along with field measurements in Appendix 1. Data is presented in parts per million unless otherwise noted.

We have also undertaken physical and chemical analysis of soil samples from all four beaches. These studies include grain size analysis and fractionated extractable phosphate. Studies are ongoing and results will be available in our annual report.

#### 4. Initial Conclusions

In focussing on N-species, pH, and dissolved oxygen, we observe two important relationships;

- A. The ground waters in the half of the beach closest to the river closely reflect river chemistry.

B. Ground waters near and under return channels are very strongly influenced by interaction with buried, overbank, flood flow deposits.

C. DO, NO<sub>3</sub>, and NO<sub>2</sub> concentrations decrease from the river to bar to return channel, while NH<sub>4+</sub>, alkalinity, total salinity and DOC increase across the same areas.

## **B. PROBLEMS ENCOUNTERED**

During reduction of the field measurements for nitrate and nitrite, we observed that regression curves for standards run on one trip (July 1994) were not satisfactory. In our subsequent discussion with Hach, our supplier, we were informed that the lot of reagents used for nitrate and nitrite analysis were bad, forcing us to question all our field nitrate and nitrite numbers from the July trip. We did collect samples for laboratory analysis of nitrate and nitrite. We will compare lab and field measurements of N-species for the April trip to determine if we can use lab values for N-species from our July trip.

We discovered large amounts of drift in our Eh measurements which we believe are due to poorly poised waters. Therefore, we added Winkler titrations to our field measurements in order to gain accurate knowledge of the oxidation states within the reattachment bars.

We have recently lost our GTR. This poses several problems, not the least of which is communicative. This project was originally funded for two years. We demonstrated that two years of sampling was necessary for statistical validity. After project startup, funds were taken back, causing a reduction in sample collection. Also, as stated in our original proposal, hydrologic data was needed to quantify flux of nutrients through the reattachment bars. These data were to be supplied to us. This has not happened. We provided our former GTR with a plan to obtain this hydrologic data, but funding was denied. We are concerned that without statistical validity and hydrologic information, our conclusions will be limited. As stated in the Draft EIS, the linkages between sediment and water need to be established. The biogeochemical reactions taking place in the reattachment bars are an important aspect of the fluvial ecosystem and need further study. Reaction paths of nutrients are dependent on two factors: water and oxygen. Fluctuating flows control the delivery of both. Any management alternative that is implemented will have profound effects on biogeochemical reactions (nutrient cycling) within the river corridor. Our ability to predict these effects will be limited by the situation described above.

## **C. FISCAL STATUS**

Due to the budget shortfall for FY93, this project has been reduced in scope. All biological objectives have been suspended. In addition, the number of sampling trips has been reduced to five. In order to offset the reduction in sampling trips, we have submitted a pre-proposal to Dr. Patten, Department of Environmental Sciences, Arizona State University to sample extensively 194L before and during the experimental flood flow during the spring of 1995. Lastly, much of the laboratory analysis of samples collected this year will be put off until FY94.

1. Cooperative Agreement Amount:\$133,849
2. Expenditures and Commitments to Date: \$90,0740
3. Estimated Funds Required to Complete Work: \$43,109
4. Estimated Date of Completion of Work: 4-1-95

Final report, final management report,final oral report.....1 June, 1995

#### **D. ACTION REQUESTED OF NPS**

1. Continued support of this project during the analysis and report preparation phases is requested of the NPS.

#### **E. FUTURE PLANS**

1. The schedule has been modified as follows.

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Table 1: Schedule for activities and deliverables.

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Initiation	March 1, 1992 or on notification of funding
Quarterly report	April 1, 1993
Initial oral report to NPS	April 15, 1993
First sampling trip	April 17, 1993
Quarterly report	July 1, 1993
Second sampling trip	July 9, 1993
Quarterly report	October 1, 1993
Third sampling trip	October 10, 1993
Draft 1993 annual technical and administrative reports	December 1, 1993
Final 1993 annual and oral reports	January 15, 1994
Fourth sampling trip	January 5, 1994
Quarterly report	April 1, 1994
Quarterly report	July 1, 1994
Sampling trip to -6 mile	July 26, 1994
Quarterly report	October 1, 1994
Sampling trip to -6 mile	November, 1994
Draft annual technical and administrative reports	December 1, 1994
Fifth sampling trip	January ,1994
Final 1994 annual and oral reports	January 30, 1995
Final technical and annual report	June 1, 1995

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### Field Measurements

**Beach:** Hidden Slough (-6 mile)

**Date:** October 21, 1993

**Notes:**

Sample	T(C)	Sp cond.	pH	[H+]	DO(ml)	NH4+	[N-NO2]	[N-NO3]
Aways average	12.35	1148	7.5	4E-08	1.20	1.35	0.00	0.03
Aways std. dev.	1.28	96	0.2	1E-08	0.51	1.25	0.00	0.03
Mid average	12.20	1056	7.5	3E-08	1.75	1.02	0.00	0.03
Mid std. dev.	1.02	108	0.2	1E-08	0.52	1.26	0.00	0.03
Close average	9.95	908	7.9	1E-08	2.23	1.15	0.01	0.27
Close std. dev.	1.20	139	0.2	2E-08	0.99	1.31	0.01	0.29
Avg. surface	7.55	869	8.2	7E-09	7.78	45.82	0.01	0.60
Std.dev.	3.32	1	0.1	9E-10	0.67	64.15	NA	NA
10AS	13.1	1188	7.5	3.1E-08	1.60	0.41	0.00	0.06
10AD	13.4	1169	7.5	2.9E-08	1.01	0.66	0.00	0.02
10BS	12.4	1060	7.5	3.5E-08	2.05	0.84	0.01	0.01
10BD	12	1058	7.6	2.3E-08	2.38	2.24	0.01	0.08
10CS	9.5	915	7.8	1.4E-08	1.97	1.34	0.01	0.06
10CD	10.7	1008	7.8	1.4E-08	1.58	2.46	0.00	0.03
30AS	11.7	1183	7.3	5.2E-08	0.99	3.93	0.00	0.01
30AD	11.2	1052	7.5	3.0E-08	1.19	0.38	0.00	0.02
30BS	12.7	1201	7.4	4.2E-08	0.97	0.66	0.01	0.01
30BD	11.7	906	7.6	2.4E-08	1.60	0.36	0.00	0.00
30CS	9.1	858	8	1.1E-08	4.00	0.43	0.01	0.85
30CD	10.5	850	7.9	1.3E-08	1.35	0.36	0.01	0.13
RC	5.2	868	8.1	7.6E-09	8.25	0.45	0.01	0.50
RIVER	9.9	869	8.2	6.3E-09	7.3	91.18	0.01	0.70

## Lab Analysis

**Beach:** Hidden Slough (-6 mile)

**Date:** October 21, 1993

**Notes:**

Sample	IC(ppm)	[CL] ppm	[SO4] ppm
Aways average	74.54	57.41	198.30
Aways std. dev.	15.85	5.76	58.13
Mid average	56.02	52.32	238.36
Mid std. dev.	16.23	5.01	53.21
Close average	43.39	46.63	205.31
Close std. dev.	20.51	7.34	45.97
Avg. surface	31.87	46.78	239.23
Std.dev.	0.47	2.61	4.11
10AS	58.23	60.49	288.35
10AD	73.38	48.45	230.90
10BS	56.98	51.59	243.44
10BD	48.92	53.21	263.16
10CS	40.08	46.28	214.43
10CD	63.43	54.53	162.21
30AS	88.17	62.99	145.98
30AD	78.39	57.70	127.96
30BS	68.97	54.36	262.83
30BD	49.22	50.12	184.02
30CS	31.99	45.24	233.93
30CD	38.05	40.50	210.69
RC	32.20	44.93	236.32
RIVER	31.54	48.62	242.13

## Field Measurements

**Beach:** Hidden Slough  
**Date:** April 23, 1994  
**Notes:** RIVER IS RISING.

Sample	T(C)	Sp cond.	pH	[H+]	DO(ml)	NH4+	[N-NO2]	[N-NO3]
aways average	15.3	1091	7.5	3.47E-08	1.1	7.0	0.00	0.03
aways std. dev.	2.15	107	0.2	9.69E-09	0.52	0.00	0.00	0.05
mid average	16.1	950	7.5	3.61E-08	1.3	7.0	0.01	0.07
mid std. dev.	2.23	83	0.2	1.35E-08	0.58	0.00	0.01	0.04
close average	16.1	876	7.9	1.43E-08	1.9	7.0	0.01	0.19
close std. dev.	1.98	92	0.3	1.64E-08	1.08	0.00	0.01	0.13
Avg. surface	15.6	850	8.7	2.85E-09	11.4	7.0	0.02	0.14
Std.dev.	6.58	17	0.5	2.58E-09	3.82	0.00	0.00	0.06
10AS	15.6	1135	7.53	2.95E-08	1.30	7.04	0.002	0.13
10AD	17.5	1086	7.50	3.16E-08	1.1	7.04	0.000	0.00
10BS	19.4	908	7.56	2.75E-08	2.2	7.04	0.010	0.08
10BD	17.2	941	7.63	2.34E-08	1.6	7.04	0.009	0.07
10CS	16.9	860	7.78	1.66E-08	1.2	7.04	0.006	0.07
10CD	13.2	889	7.78	1.66E-08	0.5	7.04	0.003	0.05
30AS	13.6	1082	7.33	4.68E-08	1	7.04	0.000	0.00
30AD	14.4	1060	7.51	3.09E-08	0.8	7.04	0.000	0.00
30BS	14.2	923	7.28	5.25E-08	0.5	7.04	0.003	0.02
30BD	13.7	1026	7.39	4.07E-08	0.8	7.04	0.020	0.11
30CS	15.3	900	7.94	1.15E-08	3.7	7.04	0.004	0.31
30CD	19.0	856	7.90	1.26E-08	2	7.04	0.014	0.33
RC	20.2	838	8.99	1.02E-09	14.1	7.04	0.013	0.09
RIVER	10.9	862	8.33	4.68E-09	8.7	7.04	0.020	0.18
30CD dup	13.0	858	7.90	1.26E-08	1.8	7.04	0.008	0.11

### Lab Analysis

**Beach:** Hidden Slough

**Date:** April 23, 1994

**Notes:** RIVER IS RISING.

Sample	[K] ppm	[Na] ppm	[Ca] ppm	[Mg] ppm	[CL] ppm	[SO4] ppm	IC ppm
aways average	3.2	79.6	97.9	28.5	54.3	195.8	77.3
aways std. dev.	0.43	6.03	14.11	3.10	18.59	56.82	17.2
mid average	3.2	72.7	80.8	24.2	72.7	229.0	52.9
mid std. dev.	0.41	5.30	10.48	3.07	18.77	52.75	17.3
close average	2.7	66.0	65.8	24.8	51.0	195.1	46.2
close std. dev.	0.75	7.17	14.05	2.81	5.57	48.39	21.1
Avg. surface	2.4	67.4	58.2	23.9	53.8	224.9	32.4
Std.dev.	0.31	0.03	2.55	1.03	0.85	6.60	NA
10AS	3.7	85.4	96.0	30.6	53.3	234.2	71.6
10AD	2.7	75.7	105.3	NA	51.6	251.8	70.2
10BS	3.2	77.7	78.2	26.0	82.3	218.4	56.1
10BD	2.4	70.2	75.0	NA	102.1	258.4	44.0
10CS	3.0	69.1	67.7	NA	55.8	227.2	39.4
10CD	3.4	69.2	71.4	NA	51.3	107.1	75.8
30AS	3.6	82.0	98.9	24.5	54.4	135.7	87.0
30AD	2.8	75.2	91.3	30.5	57.7	161.4	80.4
30BS	3.5	66.7	85.7	24.1	46.8	231.9	53.7
30BD	3.6	76.5	84.1	22.4	59.7	207.4	57.7
30CS	3.0	66.8	64.9	25.7	53.8	230.9	35.9
30CD	1.3	58.8	59.3	23.9	43.1	215.2	33.5
RC	2.6	67.4	56.4	24.6	54.4	229.6	NA
RIVER	2.2	67.4	60.0	23.1	53.2	220.2	32.4
30CD dup	2.3	62.0	64.2	25.3	50.5	229.3	35.4

## Field Measurements

**Beach:** Hidden Slough

**Date:** July 30, 1994

**Notes:** HIGH WATER

Sample	T(C)	Sp cond.	pH	[H+]	DO(ml)	NH4+
aways average	16.4	1062.0	7.5	3.33E-08	0.7	105.5
aways std. dev.	1.38	358.86	0.23	1.72E-08	0.34	38.45
mid average	18.1	1184.0	7.5	3.56E-08	1.0	139.8
mid std. dev.	1.02	373.37	0.23	1.74E-08	0.35	38.23
close average	17.0	1014.8	7.7	2.33E-08	1.1	127.3
close std. dev.	0.71	155.06	0.20	1.27E-08	0.34	42.12
Avg. surface	12.7	817.0	8.5	4.45E-09	10.8	156.0
Std.dev.	5.52	21.21	0.45	3.95E-09	4.32	2.83
10AS	15.6	1079	7.57	2.69E-08	1.05	153.00
10AD	15.0	1176	7.49	3.24E-08	0.56	137
10BS	19.4	1980	7.18	6.61E-08	1.51	134
10BD	17.2	964	7.63	2.34E-08	1.2	155
10CS	16.6	844	7.87	1.35E-08	0.96	111
10CD	16.0	970	7.80	1.58E-08	0.74	79
30AS	17.7	953	7.34	4.57E-08	0.69	80
30AD	17.3	1040	7.55	2.82E-08	0.51	52
30BS	18.2	883	7.66	2.19E-08	0.9	159
30BD	17.4	909	7.51	3.09E-08	0.49	111
30CS	17.8	1335	7.34	4.57E-08	1.4	162
30CD	17.7	910	7.74	1.82E-08	1.3	157
RC	16.6	802	8.78	1.66E-09	13.9	158
RIVER	8.8	832	8.14	7.24E-09	7.8	154

### Field Measurements

**Beach:** Hidden Slough

**Date:** July 30, 1994

**Notes:** LOW WATER

Sample	T(C)	Sp cond.	pH	[H+]	DO(ml)	NH4+
aways average	17.3	1056	7.4	3.95E-08	0.7	68.8
aways std. dev.	1.60	181.39	0.16	1.65E-08	0.33	49.28
mid average	18.8	1027	7.4	4.18E-08	0.9	138.5
mid std. dev.	1.65	192.96	0.17	1.72E-08	0.34	35.81
close average	16.4	1000	7.5	3.42E-08	1.6	125.5
close std. dev.	1.12	152.65	0.17	1.50E-08	0.73	36.18
Avg. surface	14.4	819	8.2	6.12E-09	9.2	152.5
Std.dev.	6.93	2.12	0	6.95E-10	1.05	2.12
10AS	16.4	1070	7.53	2.95E-08	1.10	7.04
10AD	18.1	1162	7.42	3.80E-08	0.9	135.00
10BS	21.1	1435	7.14	7.24E-08	1.08	135.00
10BD	16.5	957	7.55	2.82E-08	1.02	154.00
10CS	16.5	842	7.58	2.63E-08	0.91	119.00
10CD	16.4	957	7.58	2.63E-08	1.31	89.00
30AS	17.0	959	7.26	5.50E-08	0.26	80.00
30AD	17.6	1032	7.45	3.55E-08	0.59	53.00
30BS	19.1	838	7.62	2.40E-08	0.95	152.00
30BD	18.5	877	7.37	4.27E-08	0.54	113.00
30CS	16.8	1304	7.21	6.17E-08	1.41	151.00
30CD	15.8	897	7.65	2.24E-08	2.59	143.00
RC	19.3	820	8.25	5.62E-09	9.91	154.00
RIVER	9.5	817	8.18	6.61E-09	8.42	151.00

Beach:

43.2L

## Field Measurements

Date:

April 20, 1993

Notes:

Sample	T(C)	Sp. cond.	pH	[H+]	Eh	Alkalinity (meq/l)	[N-NO2]	[N-NO3]
aways average	16.6	1140	7.40	4.31E-08	155.6	5.07	0.00	0.03
awas std. dev.	1.26	115	0.28	1.79E-08	112.69	1.55	0.01	0.06
middles average	16.7	1055	7.62	2.56E-08	377.6	3.24	0.01	0.11
middles std. dev.	1.17	118	0.27	1.75E-08	103.45	1.59	0.01	0.06
close average	16.6	1041	7.77	1.88E-08	387.4	4.35	0.02	0.11
close td. dev.	0.95	118	0.26	1.70E-08	106.22	1.54	0.01	0.06
Avg. surface water	19.6	1108	8.13	7.69E-09	417.4	3.19	0.01	0.27
Std.dev.	4.22	240	0.15	2.49E-09	23.62	0.36	0.00	0.17
1AS	17.2	1100	7.73	1.86E-08	131.5	3.28	0.000	0.00
1AD	15.0	1080	7.39	4.07E-08	120.5	4.26	0.000	0.00
1BS	14.3	990	7.73	1.86E-08	335.0	2.50	0.009	0.00
1BD	17.0	1020	7.75	1.78E-08	379.5	3.39	0.015	0.11
1CS	17.5	990	7.89	1.29E-08	380.5	3.77	0.009	0.10
1CD	18.0	940	7.89	1.29E-08	369.0	4.92	0.019	0.08
2AS	16.7	1300	7.15	7.08E-08	203.9	8.41	0.000	0.00
2AD	17.0	1210	7.29	5.13E-08	145.5	5.87	0.000	0.01
2BS	18.0	1160	7.35	4.47E-08	376.8	4.25	0.009	0.17
2BD	18.0	1120	7.67	2.14E-08	320.5	2.75	0.005	0.08
2CS	14.6	1280	7.55	2.82E-08	373.7	4.61	0.019	0.12
2CD	15.5	945	8.13	7.41E-09	409.8	6.30	0.013	0.07
3AS	16.5	1040	7.44	3.63E-08	154.5	3.92	0.000	0.07
3AD	17.0	1110	7.39	4.07E-08	177.5	4.66	0.016	0.11
3BS	16.5	990	7.54	2.88E-08	444.5	3.30	0.000	0.08
3BSS	sample							
3BD	16.5	1050	7.65	2.24E-08	409.5	3.23	0.016	0.20
3CS	17.0	980	7.55	2.82E-08	406.8	3.40	0.011	0.15
3CD	17.0	1110	7.63	2.34E-08	384.8	3.10	0.024	0.14
RC	24.5	1385	8.28	5.25E-09	411.2	2.97	0.008	0.08
EVH	17.0	980	7.99	1.02E-08	443.5	2.99	0.006	0.37
EM	17.4	960	8.12	7.59E-09	397.5	3.60	0.007	0.37

**Beach:**

43.2L

**Date:**

April 20, 1993

**Notes:**

**Lab Analysis**

Sample	[K] ppm	[Na] ppm	[Ca] ppm	[Mg] ppm	[Cl] ppm	[SO4] ppm
aways average	2.43	62.07	89.73	34.45	62.32	31.80
awas std. dev.	0.43	6.63	12.00	6.66	3.21	2.24
middles average	2.38	58.16	82.50	27.38	61.81	32.90
middles std. dev.	0.44	6.66	11.87	6.97	3.18	2.27
close average	2.35	58.91	81.10	27.55	61.74	31.14
close td. dev.	0.41	6.64	12.03	7.12	3.11	2.28
Avg. surface water	1.93	58.91	76.17	29.40	62.16	33.20
Std.dev.	0.46	1.43	2.23	0.42	3.86	0.84
<b>1AS</b>	2.3	59.0	80.4	32.6	60.9	32.7
<b>1AD</b>	2.2	58.8	75.8	33.2	61.1	31.9
<b>1BS</b>	1.9	61.1	81.8	28.6	59.8	32.9
<b>1BD</b>	2.7	56.9	79.3	28.6	60.4	32.6
<b>1CS</b>	1.9	58.3	75.6	26.0	57.6	30.7
<b>1CD</b>	2.3	56.0	67.6	23.8	60.1	25.7
<b>2AS</b>	2.1	57.3	108.5	40.3	67.4	30.7
<b>2AD</b>	3.6	82.4	103.1	47.9	61.6	31.1
<b>2BS</b>	2.5	57.5	92.4	30.6	64.1	33.0
<b>2BD</b>	2.7	57.1	83.2	26.9	62.5	33.0
<b>2CS</b>	2.1	61.7	104.9	36.4	70.0	35.4
<b>2CD</b>	2.6	61.3	81.3	27.3	61.1	29.5
<b>3AS</b>	2.3	56.9	84.5	24.7	60.3	32.9
<b>3AD</b>	2.1	58.1	86.1	28.0	62.6	31.5
<b>3BS</b>	2.3	57.8	78.7	25.5	61.6	32.9
<b>3BSS</b>	no sample					
<b>3BD</b>	2.0	58.5	79.6	24.1	62.5	33.0
<b>3CS</b>	2.6	57.8	80.2	26.7	61.1	32.9
<b>3CD</b>	2.6	58.3	77.0	25.1	60.6	32.7
<b>RC</b>	2.4	59.8	73.6	29.4	66.6	34.2
<b>EVH</b>	1.4	57.3	77.4	29.0	59.5	32.7
<b>EM</b>	2.0	59.6	77.6	29.8	60.4	32.8

Beach:	43.2L	Field Measurements								
Date:	July 11 and 12, 1993									
Notes:	DO done with a probe									
Sample	T(C)	Sp cnd.	pH	[H+]	DO	Eh	NH4mv	NH4+	[N-NO2]	[N-NO3]
aways average	18.0	1070	7.5	3.71E-08	1.2	171	146.0	0.5	0.70	0.1
aways std. dev.	2.26	225	0.2	2.43E-08	0.95	80	53.3	0.7	0.65	0.08
mid average	20.2	1089	7.5	3.18E-08	1.0	142	128.0	0.3	0.01	0.0
mid std. dev.	2.15	142	0.2	1.34E-08	1.26	68	44.1	0.2	0.40	0.08
close average	21.8	931	7.5	3.18E-08	0.1	201	178.6	0.1	0.08	0.1
close std. dev.	2.11	141	0.2	1.34E-08	1.28	77	43.1	0.21	0.40	0.09
Avg. surface	18.9	925	8.0	1.04E-08	6.7	199	138.3	0.4	2.68	0.3
Std.dev.	8.03	16	0.1	2.78E-09	1.48	32	58.5	0.58	2.66	0.20
1AS	18.1	1645	6.98	1.05E-07	0.00	59	35.0	2.73	0.00	0.00
1AD	16.9	950	7.59	2.57E-08	0.00	255	202.0	0.04	2.09	0.10
1BS	22.8	1061	7.5	3.16E-08	0.71	83	129.0	0.24	0.00	0.03
1BD	20.6	866	7.7	2.00E-08	1.10	119	122.0	0.29	0.02	0.03
1CS	22.2	870	7.76	1.74E-08	0.00	230	130.0	0.23	0.03	0.07
1CD	20	810	7.73	1.86E-08	0.00	155	145.0	0.16	0.02	0.02
2AS	18.1	973	7.54	2.88E-08	3.26	134	124.0	0.27	0.01	0.07
2AD	17.1	954	7.62	2.40E-08	1.31	206	153.0	0.13	0.01	0.10
2BS	18.2	1252	7.24	5.75E-08	0.00	150	138.0	0.19	0.00	0.13
2BD	17.1	1346	7.48	3.31E-08	0.00	152	90.0	0.66	0.00	0.00
2CS	23	1010	7.21	6.17E-08	0.00	287	234.0	0.02	0.05	0.25
2CD	22.7	972	7.5	3.16E-08	0.00	358	227.0	0.02	0.04	0.12
3AS	19	959	7.62	2.40E-08	1.20	189	187.0	0.05	1.48	0.27
3AD	18.8	938	7.81	1.55E-08	1.41	182	175.0	0.07	0.60	0.09
3BS	19.4	992	7.6	2.51E-08	4.00	150	90.0	0.66	0.00	0.00
3BD	19.6	1129	7.51	3.09E-08	0.00	157	136.0	0.20	0.01	0.00
3CS	23	1016	7.63	2.34E-08	0.00	196	198.7	0.04	0.04	0.02
3CD	21.1	993	7.42	3.80E-08	0.00	168	157.4	0.12	0.00	0.00
1AD dup	NA	NA	7.63	2.34E-08	0.75	5	178.0	0.07	0.34	0.03
RC	28.2	943	8.14	7.24E-09	6.48	162	177.0	0.07	0.00	0.10
EVH	14	916	7.95	1.12E-08	8.32	217	167.0	0.09	5.33	0.36
EM	14.6	915	7.9	1.26E-08	5.39	218	71.0	1.08	2.70	0.50

**Beach:** 43.2L **Lab Analysis**

**Date:** July 11 and 12, 1993

**Notes:**

Sample	IC ppm	[Cl] ppm	[SO4] ppm
aways average	56.4	50.8	199.5
aways std. dev.	43.2	3.6	106.5
mid average	73.9	55.0	121.1
mid std. dev.	30.4	5.2	102.5
close average	54.9	47.9	127.8
close std. dev.	31.5	7.8	103.0
Avg. surface	125.4	53.4	237.7
Std.dev.	160.7	0.6	8.5
1AS	170.6	48.9	2.3
1AD	33.1	48.0	232.9
1BS	46.5	55.9	233.9
1BD	44.0	45.3	152.0
1CS	57.4	45.4	107.6
1CD	66.0	53.1	40.5
2AS	38.9	49.4	232.5
2AD	31.8	53.9	245.0
2BS	98.8	54.3	36.5
2BD	128.0	53.3	1.6
2CS	37.6	53.7	250.4
2CD	103.1	53.4	6.4
3AS	31.7	49.1	241.3
3AD	32.1	55.2	242.9
3BS	86.2	54.7	51.3
3BD	53.5	58.9	240.3
3CS	39.9	66.4	251.6
3CD	32.9	29.7	124.8
1AD dup	32.3	52.1	237.0
RC	34.2	53.3	247.2
EVH	31.1	54.1	235.5
EM	311.0	53.0	230.6

**Beach:**

43.2L

**Field Measurements**

**Date:**

October 8, 1993

**Notes:**

Samples were collected at high water, some wells (-20)  
were sampled again at low water.

Sample	T(C)	Sp cond.	pH	[H+]	DO	NH4+	[N-NO2]	[N-NO3]
aways average	17.2	1367	7.2	6.39E-08	0.8	5.3	0.0	0.0
awas std. dev.	1.03	292	0.27	2.6E-08	0.68	6.59	0.01	0.01
middles average	19.1	1352	7.4	4.45E-08	2.2	1.0	0.0	0.0
middles std. dev.	1.12	265	0.24	2.17E-08	1.42	0.76	0.01	0.02
close average	18.8	1115	7.6	2.66E-08	1.4	1.0	0.0	0.0
close td. dev.	1.05	251	0.24	2.2E-08	1.31	0.72	0.01	0.01
Avg. surface water	11.6	941.0	8.1	8.55E-09	8.9	0.1	0.0	0.4
Std.dev.	0.59	30	0.09	1.6E-09	0.68	0.03	0.01	0.12
1AS	18.2	1684	7.01	9.77E-08	0.0	25.63	BDL	BDL
1AD	16.8	1182	7.29	5.13E-08	0.5	1.09	0.01	BDL
1BS	19.2	1043	7.45	3.55E-08	1.6	0.59	0.02	0.02
1BD	18.5	1081	7.67	2.14E-08	1.8	1.51	0.02	0.02
1CS	19.2	1227	7.57	2.69E-08	0.9	1.94	0.01	0.03
1CD	18.7	890	7.82	1.51E-08	1.5	1.33	0.02	0.04
2AS	16.6	1420	7.22	6.03E-08	0.9	2.30	0.00	BDL
2AD	16.6	1368	7.23	5.89E-08	0.6	2.03	BDL	BDL
2BS	19.2	1994	7.02	9.55E-08	1.8	0.31	0.01	0.04
2BD	18.7	1566	7.36	4.37E-08	0.4	2.10	0.00	BDL
2CS	19.5	1120	7.42	3.80E-08	2.6	0.17	BDL	0.04
2CD	18.5	1082	7.87	1.35E-08	1.4	0.80	BDL	0.02
3AS	18.1	1338	7.18	6.61E-08	1.3	0.45	0.01	0.03
3AD	17.0	1209	7.31	4.90E-08	1.3	0.31	0.01	0.06
3BS	20.0	1332	7.42	3.80E-08	6.4	0.88	BDL	BDL
3BD	19.1	1093	7.48	3.31E-08	1.0	0.73	0.00	0.02
3CS	20.2	1299	7.26	5.50E-08	1.8	0.12	0.01	0.06
3CD	18.3	1056	7.57	2.69E-08	1.4	0.43	BDL	0.03
1BS-2	18.5	1033	7.53	2.95E-08	1.2	0.78	0.00	0.04
1BD-2	17.7	1201	7.68	2.09E-08	1.3	1.36	0.00	0.04
1CS-2	18.3	1260	7.65	2.24E-08	0.7	1.73	0.00	0.03
1CD-2	17.6	989	7.83	1.48E-08	1.2	1.11	0.01	0.05
RC	11.4	976	8.17	6.76E-09	8.4	0.12	0.02	0.31
EVH	11.2	924	8.04	9.12E-09	8.7	0.07	BDL	0.33
EM	12.3	923	8.01	9.77E-09	9.7	0.07	0.01	0.53

**Beach:** 43.2L **Lab Analysis**

**Date:** October 8, 1993

**Notes:**

Sample	[K] ppm	[Na] ppm	[Ca] ppm	[Mg] ppm	[Cl] ppm	[SO4] ppm
aways average	1.5	82.2	249.2	48.8	59.2	125.4
awas std. dev.	0.78	11.29	70.74	12.76	15.37	92.87
middles average	1.3	86.8	265.5	44.2	73.9	163.1
middles std. dev.	0.57	11.25	69.19	10.30	15.96	91.36
close average	1.2	80.8	190.5	34.6	63.5	170.9
close td. dev.	0.56	11.06	68.27	10.13	14.94	84.33
Avg. surface water	1.2	61.6	139.9	24.3	49.9	254.4
Std.dev.	0.36	8.20	29.69	3.83	0.36	12.37
<b>1AS</b>	3.05	79.61	266.21	71.20	57.04	5.54
<b>1AD</b>	0.77	76.68	213.97	40.61	55.68	68.92
<b>1BS</b>	0.90	74.11	180.75	30.98	55.03	233.04
<b>1BD</b>	0.98	81.84	195.14	36.28	63.34	184.98
<b>1CS</b>	0.47	93.88	220.69	37.48	75.32	182.98
<b>1CD</b>	0.41	75.10	159.59	27.86	59.17	127.46
<b>2AS</b>	0.46	80.91	280.48	53.07	68.95	167.09
<b>2AD</b>	0.93	84.74	269.69	48.93	62.07	165.99
<b>2BS</b>	1.42	116.77	433.40	65.80	113.37	281.36
<b>2BD</b>	2.01	79.48	319.03	52.75	61.71	8.35
<b>2CS</b>	1.00	77.39	197.55	33.99	60.10	263.63
<b>2CD</b>	1.39	81.37	185.12	38.16	57.89	6.78
<b>3AS</b>	2.42	94.01	244.24	38.93	50.14	210.65
<b>3AD</b>	1.53	76.97	220.56	40.28	61.48	134.23
<b>3BS</b>	1.60	94.17	271.33	48.59	90.70	45.44
<b>3BD</b>	0.97	74.54	193.06	30.81	59.09	225.52
<b>3CS</b>	1.39	84.91	230.64	41.79	69.00	293.32
<b>3CD</b>	1.30	72.67	177.31	32.40	57.87	158.94
<b>1BS-2</b>	1.33	71.90	168.83	29.89	54.82	230.19
<b>1BD-2</b>	1.98	82.52	201.54	39.91	75.14	229.43
<b>1CS-2</b>	1.82	87.78	201.83	37.15	70.63	188.54
<b>1CD-2</b>	1.69	73.22	151.06	28.01	58.41	145.60
<b>RC</b>	1.47	67.42	163.87	27.00	50.21	268.65
<b>EVH</b>	0.96	65.05	149.26	26.02	49.50	246.99
<b>EM</b>	BDL	52.19	106.72	19.93	49.88	247.47

**Beach:** 43.2L **Field Measurements**

**Date:** January 4 and 5, 1994

**Notes:** Ammonia probe failure

Sample	T(C)	Sp cond.	pH	[H+]	DO	[NO2]	[NO3]
aways average	11.6	1377	7.1	1.03E-07	1.45	0.13	0.04
awas std. dev.	1.23	433.6	0.36	6.43E-08	0.87	0.06	0.01
middles average	13.0	1050	7.2	7.96E-08	1.52	0.10	0.03
middles std. dev.	1.65	392.9	0.31	4.40E-08	0.68	0.04	0.01
close average	11.8	1043	7.4	4.76E-08	2.10	0.07	0.06
close td. dev.	1.57	391.6	0.27	2.63E-08	0.66	0.04	0.05
Avg. surface water	10.1	796	7.3	5.12E-08	9.20	0.04	0.18
Std.dev.	0.35	4.6	0.14	1.73E-08	0.95	0.01	0.06
1AS	11.2	1743	6.62	2.4E-07	0.0	BDL	BDL
1AD	12.3	1424	6.94	1.15E-07	0.7	BDL	BDL
1BS	10.0	1025	6.73	1.86E-07	2.3	BDL	0.03
1BD	11.4	1203	7.48	3.31E-08	2.4	BDL	0.03
1CS	10.6	1180	7.85	1.41E-08	2.1	BDL	0.03
1CD	11.8	794	7.88	1.32E-08	1.9	BDL	0.03
2AS	10.7	1617	7.13	7.41E-08	2.6	BDL	BDL
2AD	10.4	930	7.26	5.5E-08	2.7	BDL	0.04
2BS	13.3	2.22	6.95	1.12E-07	1.0	BDL	0.00
2BD	14.2	1627	7.28	5.25E-08	0.7	BDL	BDL
2CS	10.6	1067	7.16	6.92E-08	2.6	BDL	0.03
2CD	12.2	1012	7.35	4.47E-08	2.2	BDL	BDL
3AS	11.8	1231	7.08	8.32E-08	0.9	0.08	BDL
3AD	13.1	1318	7.30	5.01E-08	1.8	0.17	0.03
3BS	13.9	1288	7.32	4.79E-08	1.3	0.12	BDL
3BD	15.4	1152	7.34	4.57E-08	1.4	0.08	0.05
3CS	11.6	1138	7.09	8.13E-08	2.2	0.08	0.16
3CD	13.7	1064	7.20	6.31E-08	1.6	0.06	0.07
RC	10.4	795	7.15	7.08E-08	8.1	0.03	0.10
EVH	9.7	801	7.42	3.8E-08	9.8	0.05	0.22
EM	10.1	792	7.35	4.47E-08	9.7	0.03	0.21

**Beach:** 43.2L **Lab Analysis**

**Date:** January 4 and 5, 1994

**Notes:**

Sample	IC ppm	[Cl]	[SO4]
aways average	94.9	50.4	125.6
awas std. dev.	42.35	17.80	106.13
middles average	86.1	60.0	220.9
middles std. dev.	34.82	17.73	96.46
close average	57.6	60.1	128.3
close td. dev.	34.77	17.41	96.25
Avg. surface water	22.2	40.2	202.1
Std.dev.	0.90	1.56	2.76
1AS	170.7	57.59	0.35
1AD	115	63.28	2.06
1BS	37.14	50.63	254.30
1BD	55.4	67.45	208.70
1CS	74.055	75.99	50.86
1CD	53.358	52.40	20.18
2AS	104	77.15	179.07
2AD	36.53	49.09	212.02
2BS	134.8	68.90	173.73
2BD	139.6	54.44	BDL
2CS	45.319	55.38	252.24
2CD	82.33	60.65	1.78
3AS	53.26	52.34	265.53
3AD	90.01	3.14	94.52
3BS	104.7	58.66	BDL
3BD	45.1	60.06	246.79
3CS	44.24	58.03	260.75
3CD	46.31	58.27	183.99
RC	22.87	40.19	204.23
EVH	21.181	38.71	199.00
EM	22.557	41.83	203.16

## Field Measurements

**Beach:** 71.2L  
**Date:** April 23, 1993  
**Notes:**

Sample	T(C)	Sp cond.	pH	[H+]	Eh	[N-NO2]	[N-NO3]
aways average	17.3	1248.3	7.5	4.12E-08	219.6	0.0	0.1
awas std. dev.	2.79	232.3731	0.25	2.57E-08	94.54	0.01	0.06
middles average	15.0	1115.7	7.7	1.98E-08	269.0	0.0	0.1
middles std. dev.	2.68	235.1711	0.26	2.61E-08	96.24	0.01	0.07
IAS	14.5	1200	7.68	2.09E-08	317.0	0.007	0.04
IAD	19.0	1215	7.55	2.82E-08	318.0	0.013	0.14
IBS	13.5	1015	7.84	1.45E-08	398.0	0.008	0.11
IBS dup	13.1	1005	7.76	1.74E-08	358.0	0.010	0.14
IBD	13.5	890	7.63	2.34E-08	154.0	0.000	0.00
IIAS	20.0	1475	7.38	4.17E-08	172.5	0.000	0.01
IID	17.0	1105	7.53	2.95E-08	197.0	0.000	0.08
IBS	18.5	1645	7.50	3.16E-08	322.0	0.000	0.06
IBD	11.5	985	7.92	1.2E-08	203.0	0.014	0.13
IIIAS	17.5	1390	6.98	1.05E-07	113.0	0.000	0.00
IIID	15.5	1105	7.65	2.24E-08	200.0	0.021	0.16
IIIBS	17.0	1210	7.60	2.51E-08	140.0	0.000	0.07
IIIBD	18.0	1060	7.83	1.48E-08	308.0	0.012	0.19
RIVER	3.5	940	8.08	8.32E-09	334.0	0.018	0.35

### Lab Analysis

**Beach:** 71.2L  
**Date:** April 23, 1993  
**Notes:**

Sample	Alk. (meq/l)	[Cl] ppm	[SO4] ppm
aways average	6.2	89.4	204.6
awas std. dev.	3.28	8.03	43.36
middles average	8.1	85.9	163.4
middles std. dev.	3.51	11.37	54.38
IAS	5.45	86.7	199.6
IAD	7.45	90.0	194.9
IBS	7.90	72.5	187.8
IBS dup	NA	NA	NA
IBD	12.02	78.9	124.9
IIAS	7.74	96.3	169.3
IIAD	4.21	80.7	223.8
IBS	13.04	86.0	103.5
IIBD	4.09	82.8	207.9
IIIAS	8.91	99.4	191.7
IIIAID	3.41	83.2	248.5
IIIBS	8.46	110.8	107.3
IIIBD	3.29	84.2	249.1
RIVER	NA	80.4	240.5

## Field Measurements

**Beach:** 71.2L

**Date:** July 15 and 16, 1993

**Notes:** IAS, IAD, IIAD, IIAS, IIBS, and IIIBD are filled with sediment  
and have tp be redeveloped. IAD, after redeveloping has  
13" of sediment and recharges slowly.

**Nitrite and Nitrate numbers are suspect due to bad reagents!**

Sample	T(C)	Sp cond.	pH	[H+]	DO	NH4+
aways average	17.3	1461	7.3	6.02E-08	1.6	0.4
awas std. dev.	2.35	388	0.22	3.03E-08	1.38	0.2
middles average	17.2	1296	7.4	4.86E-08	2.1	0.2
middles std. dev	1.83	420	0.25	3.28E-08	1.78	0.2
<b>IAS</b>	16.5	1333	7.4	4E-08	1.1	0.2
<b>IAD</b>	21.8	1686	7.16	6.9E-08	0.6	0.6
<b>IIS</b>	20.9	1187	7.5	3.2E-08	2.13	0.1
<b>IBD</b>	14.9	1525	7.05	8.9E-08	1.06	0.3
<b>IIAS</b>	17.3	1175	7.41	3.9E-08	0.5	0.2
<b>IIAD</b>	16.7	1266	7.26	5.5E-08	0.2	0.6
<b>IIBS</b>	18.8	2037	7.03	9.3E-08	0.1	0.6
<b>IIIBD</b>	16.3	1015	7.61	2.5E-08	0.7	0.2
<b>IIIAS</b>	16.4	2145	6.94	1.1E-07	3.23	0.4
<b>IIIAID</b>	14.9	1158	7.36	4.4E-08	4.23	0.2
<b>IIIBS</b>	16.7	1005	7.57	2.7E-08	4.69	0.1
<b>IIIBD</b>	15.6	1008	7.58	2.6E-08	3.76	0.1
<b>RIVER</b>	16.6	964	7.87	1.3E-08	9.49	0.0
<b>RC</b>	21.4	1211	8.38	4.2E-09	2.6	0.0

### Lab Analysis

**Beach:** 71.2L  
**Date:** July 15 and 16, 1993  
**Notes:**

Sample	[K] ppm	[Na] ppm	[Ca] ppm	[Mg] ppm	[Cl] ppm	[SO4] ppm	IC ppm
aways average	1.1	102.4	208.6	46.6	80.4	49.0	115.37
awas std. dev.	0.9	19.7	78.5	15.4	31.0	77.5	37.47
middles average	1.3	85.8	222.0	44.9	54.6	136.1	89.93
middles std. dev	0.9	10.5	87.4	16.8	32.5	65.6	45.87
IAS	0.1	92.0	224.2	45.4	97.9	2.65	130.90
IAD	2.4	147.1	224.1	47.0	68.6	9.77	150.10
IBS	1.6	81.7	199.2	41.3	79.7	157.11	78.21
IBD	2.3	84.9	285.7	39.6	1.5	BDL	134.40
IIAS	0.4	89.7	177.1	39.3	90.8	76.63	98.73
IID	1.2	89.0	166.4	44.8	70.1	0.28	124.70
IBS	2.4	103.0	402.3	84.4	85.9	46.27	179.57
IBD	0.7	87.4	164.4	38.1	81.8	229.55	70.68
IIIAS	2.0	111.4	302.0	67.1	110.9	114.62	125.80
IIID	0.6	85.3	157.6	36.2	44.0	89.95	61.97
IIIBS	0.0	81.3	133.9	34.0	38.7	127.66	36.68
IIIBD	0.6	76.6	146.6	31.9	39.8	119.70	40.06
RIVER	1.2	76.4	142.6	29.0	71.8	282.87	32.16
RC	2.2	109.0	150.9	31.5	110.0	384.79	32.08

## Field Analysis

**Beach:** 71.2L

**Date:** October 11, 1993

**Notes:** IB wells have been washed away. Probably due to a flash flood in Cardenas Creek. No return channel sample this time.

Sample	T(C)	Sp cond.	pH	[H+]	DO	[NH4]	[NO2]	[NO3]
aways average	16.5	1486	7.2	6.80E-08	1.0	3.3	0.0	0.0
awas std. dev.	1.24	334	0.27	4.15E-08	1.78	2.65	0.00	0.06
middles average	15.3	1375	7.5	4.30E-08	1.8	2.0	0.0	0.1
middles std. dev	0.74	401	0.35	5.03E-08	1.57	1.84	0.00	0.07
IAS	17.8	1305	7.4	4.47E-08	4.2	0.63	0.00	0.00
IAI	18.8	1475	7.5	3.31E-08	0.4	1.43	0.00	0.00
IAD	16.9	1822	7.1	7.76E-08	2.0	8.03	0.00	0.00
IIAS	15.8	1207	7.5	3.39E-08	0.5	1.50	0.00	0.00
IIAD	15.3	1211	7.3	5.62E-08	0.4	5.22	0.00	0.00
IBS	16.0	2090	7.0	1.00E-07	0.0	5.47	0.00	0.18
IIBD	15.3	1169	7.7	2.19E-08	4.1	1.24	0.00	0.02
IIIAS	16.4	1620	6.8	1.45E-07	0.0	2.80	0.00	0.00
IIIAID	14.8	1160	7.3	5.37E-08	0.3	1.50	0.00	0.00
IIIBS	15.3	1212	7.6	2.63E-08	1.6	0.43	0.00	0.02
IIIBD	14.4	1030	7.6	2.40E-08	1.4	1.02	0.00	0.02
RIVER	12.6	989	8.2	6.92E-09	9.4	0.11	0.01	0.40

Lab Analysis

**Beach:** 71.2L  
**Date:** October 11, 1993  
**Notes:**

Sample	[Cl]	[SO4]
aways average	99.4	76.8
awas std. dev.	31.07	66.50
middles averag	95.8	149.7
middles std. de	28.54	89.21
IAS	81.36	BDL
IAI	73.63	BDL
IAD	136.56	5.46
IIAS	81.36	161.21
IIAD	68.01	25.16
IBS	143.84	14.50
IIBD	78.46	136.57
IIIAS	125.25	80.31
IIID	85.23	173.94
IIIBS	86.67	275.21
IIIBD	74.30	172.62
RIVER	72.54	223.28

## Field Measurements

**Beach:** 71.2L  
**Date:** January 7, 1994  
**Notes:**

Sample	T(C)	Sp cond.	pH	[H+]	DO	[NH4]	[NO2]	[NO3]
aways average	11.0	1391	7.3	5.11E-08	0.9	3.0	BDL	BDL
awas std. dev.	0.89	282	0.23	3.23E-08	0.58	2.55	BDL	BDL
middles average	10.8	1299	7.5	4.29E-08	1.2	2.0	0.0	0.1
middles std. dev.	0.93	336	0.36	4.41E-08	0.79	1.84	0.00	0.08
IAS	11.0	1404	7.39	4.07E-08	1.4	0.6	BDL	BDL
IAI	9.8	1504	7.49	3.24E-08	0.8	1.4	BDL	BDL
IAD	11.3	1810	7.33	4.68E-08	1.1	8.0	BDL	BDL
IIAS	11.6	1210	7.47	3.39E-08	1.2	1.5	BDL	BDL
IIAD	12.5	1264	7.27	5.37E-08	0.6	5.2	BDL	BDL
IBS	11.6	1906	6.96	1.10E-07	0	5.5	BDL	0.2
IIBD	11.5	1152	7.61	2.45E-08	1.4	1.2	0.00	0.0
IIIAS	9.7	1442	6.96	1.10E-07	0	2.8	BDL	BDL
IIIAID	11.1	1103	7.39	4.07E-08	1.5	1.5	BDL	BDL
IIIBS	9.4	1148	7.68	2.09E-08	1.7	0.4	BDL	0.0
IIIBD	10.5	991	7.78	1.66E-08	1.5	1.0	0.00	0.0
RIVER	9.0	879	8.10	7.94E-09	9.6	0.1	0.01	0.4

### Lab Analysis

**Beach:** 71.2L  
**Date:** January 7, 1994  
**Notes:**

Sample	[Cl] ppm	[SO4] ppm	[K] ppm	[Na] ppm	[Ca] ppm	[Mg] ppm
aways average	77.0	59.0	1.4	102.1	100.0	46.0
awas std. dev.	20.2	92.2	0.5	26.6	26.8	11.0
middles average	93.1	100.5	0.7	89.5	91.5	44.0
middles std. dev	24.7	87.0	0.6	13.3	29.9	13.8
IAS	84.4	1.4	0.8	92.7	123.7	50.4
IAI	73.7	0.1	0.9	109.0	133.7	59.6
IAD	75.1	1.2	2.1	164.7	104.5	43.9
IIAS	86.7	170.2	1.4	95.5	81.5	40.2
IIAD	72.0	2.3	1.7	84.0	80.3	44.7
IBS	128.9	6.0	1.4	112.8	145.4	68.6
IIBD	92.2	144.2	0.9	82.5	75.6	37.0
IIIAS	55.7	6.6	1.8	92.2	102.2	49.1
IIID	91.5	231.1	1.0	76.7	73.8	34.0
IIIBS	78.7	128.8	0.2	81.8	81.5	38.6
IIIBD	72.5	123.0	0.4	80.9	63.5	31.7
RIVER	62.0	227.6	1.3	68.9	56.6	25.5

**Field Measurements**

<b>Beach:</b>	194L						
<b>Date:</b>	April 27, 1993						
<b>Notes:</b>							
<b>Sample</b>	<b>T(C)</b>	<b>Sp cond.</b>	<b>pH</b>	<b>[H+]</b>	<b>Eh</b>	<b>[N-NO2]</b>	<b>[N-NO3]</b>
aways average	20.3	1143.6	7.6	3.06E-08	190.4	0.0	0.1
awas std. dev.	2.44	233.97	0.3	1.3E-08	108.2	0.01	0.19
middles average	21.2	1061.7	7.9	1.54E-08	359.3	0.0	0.1
middles std. dev.	2.66	255.15	0.3	1.30E-08	107.7	0.00	0.19
close average	22.7	1002.5	8.0	1.18E-08	374.1	0.0	0.2
close td. dev.	2.74	270.95	0.3	1.35E-08	109.0	0.01	0.20
Avg. surface water	19.8	1055.0	8.3	5.07E-09	340.9	0.0	0.8
Std.dev.	1.06	21.21	0	8.25E-11	82.7	0	0.05
<b>50AD</b>	<b>20.8</b>	<b>1015</b>	<b>7.39</b>	<b>4.07E-08</b>	<b>137.5</b>	<b>0.00</b>	<b>0.00</b>
<b>100AS</b>	<b>23.0</b>	<b>1185</b>	<b>7.65</b>	<b>2.24E-08</b>	<b>222.5</b>	<b>0.00</b>	<b>0.00</b>
<b>100AD</b>	<b>20.5</b>	<b>985</b>	<b>7.89</b>	<b>1.29E-08</b>	<b>245.5</b>	<b>0.00</b>	<b>0.06</b>
<b>100BS</b>	<b>22.0</b>	<b>1340</b>	<b>7.60</b>	<b>2.51E-08</b>	<b>385.1</b>	<b>0.00</b>	<b>0.04</b>
<b>100BD</b>	<b>21.5</b>	<b>1190</b>	<b>7.66</b>	<b>2.19E-08</b>	<b>287.1</b>	<b>BDL</b>	<b>0.29</b>
<b>100CS</b>	<b>27.5</b>	<b>1230</b>	<b>7.87</b>	<b>1.35E-08</b>	<b>372.1</b>	<b>BDL</b>	<b>0.67</b>
<b>100CD</b>	<b>25.3</b>	<b>1100</b>	<b>8.02</b>	<b>9.55E-09</b>	<b>390.1</b>	<b>BDL</b>	<b>0.47</b>
<b>200AS1*</b>	<b>21.0</b>	<b>1550</b>	<b>7.28</b>	<b>5.25E-08</b>	<b>111.0</b>	<b>0.00</b>	<b>0.22</b>
<b>200AD</b>	<b>21.3</b>	<b>1220</b>	<b>7.76</b>	<b>1.74E-08</b>	<b>368.5</b>	<b>0.00</b>	<b>0.26</b>
<b>200BS</b>	<b>21.5</b>	<b>1395</b>	<b>7.70</b>	<b>2.00E-08</b>	<b>369.5</b>	<b>0.00</b>	<b>0.20</b>
<b>200BD</b>	<b>20.5</b>	<b>1140</b>	<b>8.00</b>	<b>1.00E-08</b>	<b>339.2</b>	<b>0.01</b>	<b>0.18</b>
<b>200CS</b>	<b>20.0</b>	<b>1145</b>	<b>7.68</b>	<b>2.09E-08</b>	<b>372.8</b>	<b>0.00</b>	<b>0.22</b>
<b>200CD</b>	<b>20.0</b>	<b>905</b>	<b>8.05</b>	<b>8.91E-09</b>	<b>346.8</b>	<b>0.01</b>	<b>0.08</b>
<b>300AS1*</b>	<b>18.0</b>	<b>960</b>	<b>7.52</b>	<b>3.02E-08</b>	<b>131.4</b>	<b>0.00</b>	<b>0.00</b>
<b>300AS2*</b>	<b>17.5</b>	<b>1090</b>	<b>7.42</b>	<b>3.80E-08</b>	<b>116.4</b>	<b>BDL</b>	<b>BDL</b>
<b>300BS</b>	<b>19.0</b>	<b>650</b>	<b>7.99</b>	<b>1.02E-08</b>	<b>401.5</b>	<b>0.02</b>	<b>0.06</b>
<b>300BD</b>	<b>22.7</b>	<b>655</b>	<b>8.28</b>	<b>5.25E-09</b>	<b>373.5</b>	<b>0.00</b>	<b>0.00</b>
<b>300CS</b>	<b>20.0</b>	<b>975</b>	<b>7.93</b>	<b>1.17E-08</b>	<b>367.5</b>	<b>0.01</b>	<b>0.01</b>
<b>300CD</b>	<b>23.5</b>	<b>660</b>	<b>8.19</b>	<b>6.46E-09</b>	<b>395.5</b>	<b>0.00</b>	<b>0.04</b>
<b>EM</b>	<b>20.5</b>	<b>1070</b>	<b>8.29</b>	<b>5.13E-09</b>	<b>399.4</b>	<b>0.00</b>	<b>0.76</b>
<b>HM</b>	<b>19.0</b>	<b>1040</b>	<b>8.30</b>	<b>5.01E-09</b>	<b>282.4</b>	<b>0.00</b>	<b>0.83</b>

Lab Analysis

**Beach:** 194L  
**Date:** April 27, 1993  
**Notes:**  

Sample	[Cl]	[SO4]
aways average	80.9	248.5
awas std. dev.	24.93	82.94
middles average	73.5	206.0
middles std. dev.	27.42	91.10
close average	65.9	192.1
close td. dev.	26.11	102.93
Avg. surface water	82.0	213.5
Std.dev.	0.72	1.26
50AD	76.7	208.2
100AS	68.8	197.2
100AD	69.9	215.3
100BS	136.2	285.5
100BD	76.8	200.4
100CS	84.2	251.3
100CD	74.5	217.1
200AS*	79.6	241.7
200AD	87.4	278.5
200BS	96.6	396.5
200BD	80.4	239.7
200CS	80.8	248.4
200CD	78.1	224.6
300AS1*	90.8	257.5
300AS2*	93.0	341.2
300BS	25.4	60.0
300BD	25.6	53.9
300CS	53.1	156.7
300CD	24.9	54.5
EM	81.5	214.4
HM	82.5	212.7

## Field Measurements

**Beach:** 194L

**Date:** July 20 and 21, 1993

**Notes:**

Sample	T(C)	Sp cond.	pH	[H+]	DO	NH4mv	[NH4+]	[NO2]	[NO3]
aways average	18.9	1447.7	7.3	4.96E-08	2.7	103.9	1.3	0.0	0.0
awas std. dev.	1.9	412.2	0.3	1.79E-08	1.2	29.0	0.8	0.0	0.0
middles average	20.7	1016.0	7.8	2.10E-08	2.5	140.7	0.4	0.0	0.0
middles std. dev.	1.9	412.6	0.3	1.77E-08	0.9	25.3	0.6	0.0	0.0
close average	21.1	1027.2	7.8	1.88E-08	3.1	154.8	0.1	0.0	0.0
close td. dev.	1.9	472.4	0.3	1.86E-08	0.8	25.9	0.6	0.0	0.0
Avg. surface wate	18.5	943.5	8.3	4.95E-09	8.0	165.5	0.1	0.0	0.1
Std.dev.	0.4	0.7	0.0	8.07E-11	0.2	14.8	0.1	0.0	0.0
50AD	18.4	1657	7.2	5.9E-08	1.2	85.00	2.42	0.00	0.00
100AS	18.9	1716	7.4	3.6E-08	5.7	89.00	2.05	0.00	0.00
100AD	17.2	919	7.3	4.8E-08	3.0	97.00	1.47	0.00	0.00
100BS	18.2	1403	7.4	3.8E-08	2.1	148.00	0.18	0.00	0.00
100BD	18	1423	7.5	3.2E-08	1.2	104.00	1.10	0.00	0.00
100CS	21.7	1427	7.6	2.8E-08	4.8	159.00	0.11	0.04	0.03
100CD	19.9	1313	7.7	2.1E-08	2.7	141.00	0.23	0.03	0.03
200AS*	21.6	1677	7.1	7.2E-08	1.8	87.20	2.21	0.00	0.00
200AD	19.4	2003	7.4	4.5E-08	2.7	138.00	0.27	0.00	0.00
200BS	21.7	1278	7.6	2.3E-08	2.1	165.90	0.08	0.02	0.03
200BD	19.6	974	7.8	1.6E-08	3.0	113.10	0.75	0.00	0.02
200CS	20.3	1162	7.6	2.4E-08	2.7	165.00	0.09	0.02	0.02
200CD	18.9	1232	7.8	1.5E-08	2.4	130.00	0.37	0.00	0.00
300AS1*	18.5	809	7.5	3.5E-08	2.4	125.50	0.26	0.00	0.03
300AS2*	18.4	1353	7.3	5.1E-08	2.4	105.40	0.67	0.00	0.00
300BS	24.2	515	8.0	1.1E-08	3.9	152.00	0.08	0.00	0.08
300BD	22.4	503	8.2	6.5E-09	2.7	161.30	0.05	0.00	0.11
300CS	23.5	529	7.8	1.7E-08	3.0	168.90	0.03	0.00	0.06
300CD	22.4	500	8.1	8.9E-09	3.0	165.00	0.04	0.00	0.07
EM	18.2	943	8.3	5E-09	8.1	155.00	0.13	0.04	0.06
HM	18.8	944	8.3	4.9E-09	7.8	176.00	0.05	0.02	0.11
RC	20.6	967	8.05	8.9E-09	2.9	150	0.16	0.04	0.12

### Lab Analysis

**Beach:** 194L

**Date:** July 20 and 21, 1993

**Notes:**

Sample	[IC] ppm	[Cl] ppm	[SO4] ppm
aways average	81.3	95.3	229.7
awas std. dev.	28.0	41.4	134.8
middles average	59.6	60.3	157.2
middles std. dev.	18.8	44.0	135.2
close average	51.9	67.8	201.9
close td. dev.	16.2	48.7	148.8
Avg. surface water	30.5	66.1	228.0
Std.dev.	1.9	1.4	0.0
50AD	138.2	116.48	9.25
100AS	113.81	79.88	225.49
100AD	49.96	50.16	141.01
100BS	74.05	93.77	249.34
100BD	99.25	78.35	128.49
100CS	50.98	114.33	356.96
100CD	78.23	82.69	228.32
200AS*	93.3	95.23	269.47
200AD	56.42	199.64	581.79
200BS	51.86	91.18	290.28
200BD	55.87	51.64	174.71
200CS	52.28	78.42	252.05
200CD	53.46	85.49	271.40
300AS1*	48.57	36.94	123.41
300AS2*	69.045	89.10	257.52
300BS	37.783	24.40	49.21
300BD	38.93	22.34	50.95
300CS	40.75	23.37	49.93
300CD	35.77	22.40	52.57
EM	29.19	67.04	228.06
HM	31.807	65.06	228.00
RC	32.32	71.00	231.83

## Field Measurements

**Beach:** 194L

**Date:** October 21, 1993

**Notes:** 100CS is dry at beginning of sampling

Concentrations are in ppm

Sample	T(C)	Sp cond.	pH	[H+]	DO(ml)	NH4 mv	NH4+	[N-NO2]	[N-NO3]
aways average	18.9	1210.0	6.9	1.51E-07	1.0	90.9	0.0	0.0	0.1
awas std. dev.	1.58	302.58	0.3	6.23E-08	0.54	17.37	0.03	0.04	0.07
middles average	21.6	945.8	7.1	8.66E-08	1.5	117.5	0.0	0.1	0.1
middles std. dev.	1.39	251.45	0.3	6.34E-08	0.51	14.46	0.01	0.04	0.06
close average	21.4	1081.2	7.2	7.46E-08	1.9	124.3	0.0	0.1	0.2
close td. dev.	1.75	297.75	0.2	6.14E-08	0.47	16.05	0.01	0.04	0.06
Avg. surface wtr	15.9	966.5	8.2	7.23E-09	9.6	145.5	0.0	0.1	0.5
Std.dev.	0.49	3.54	0.1	2.09E-09	0.14	3.54	0.00	0.04	0.18
50AD	17.8	1773	6.8	1.74E-07	0.3	73	0.12	0.00	0.00
100AS	18.6	1476	7.2	6.03E-08	1.3	88	0.03	0.01	0.00
100AD	18.2	917	7.3	5.13E-08	1.1	91	0.02	0.01	0.16
100BS	21.6	1201	6.9	1.15E-07	0.7	126	0	0.10	0.15
100BD	20.2	1201	7.3	4.57E-08	1.1	105	0.01	0.00	0.02
100CS	19.7	1287	7.1	7.59E-08	2	129	0	0.09	0.18
100CD	20.7	1055	7.5	3.02E-08	1.8	114	0	0.06	0.21
200AS*	20.1	NA	6.6	2.51E-07	0.4	83	0.05	0.00	0.01
200AD	20.6	1070	6.7	1.82E-07	0.9	104	0.01	0.00	0.08
200BS	20.8	1023	7	9.12E-08	1.6	125	0	0.03	0.20
200BD	20.9	931	7.1	8.51E-08	1.7	101	0.01	0.03	0.12
200CS	20.6	1488	7.1	7.94E-08	1.8	127	0	0.04	0.21
200CD	20.1	1402	7.3	5.50E-08	1.8	108	0	0.01	0.15
300AS1*	18.7	992	6.8	1.78E-07	1.2	103	0.01	0.09	0.16
300AS2*	18.5	1032	6.8	1.58E-07	1.9	94	0.03	0.05	0.11
300BS	24	775	6.9	1.29E-07	1.9	119	0	0.09	0.11
300BD	22.3	544	7.3	5.37E-08	1.7	129	0	0.11	0.14
300CS	24	756	6.9	1.26E-07	2.1	133	0	0.10	0.19
300CD	23.2	499	7.1	8.13E-08	1.7	135	0	0.10	0.21
EM(eddy)	16.2	964	8.1	8.71E-09	9.5	143	0	0.13	0.63
HM(river)	15.5	969	8.2	5.75E-09	9.7	148	0	0.07	0.37

### Lab Analysis

**Beach:** 194L  
**Date:** October 21, 1993  
**Notes:** 100CS is dry at beginning

Sample	[CL] ppm	[SO4] ppm
aways average	65.0	171.9
awas std. dev.	58.05	135.07
middles average	84.6	200.1
middles std. dev.	59.22	132.46
close average	75.6	229.0
close td. dev.	38.18	111.04
Avg. surface water	67.5	200.7
Std.dev.	0.98	0.86
<b>50AD</b>	<b>2.1</b>	<b>0.0</b>
<b>100AS</b>	<b>63.1</b>	<b>146.7</b>
<b>100AD</b>	<b>52.5</b>	<b>148.0</b>
<b>100BS</b>	<b>260.4</b>	<b>550.3</b>
<b>100BD</b>	<b>75.4</b>	<b>137.1</b>
<b>100CS</b>	<b>102.1</b>	<b>310.7</b>
<b>100CD</b>	<b>89.3</b>	<b>237.2</b>
<b>200AS*</b>	<b>147.4</b>	<b>373.8</b>
<b>200AD</b>	<b>74.9</b>	<b>221.7</b>
<b>200BS</b>	<b>61.2</b>	<b>187.3</b>
<b>200BD</b>	<b>53.3</b>	<b>163.9</b>
<b>200CS</b>	<b>101.9</b>	<b>338.1</b>
<b>200CD</b>	<b>114.0</b>	<b>358.7</b>
<b>300AS1*</b>	<b>51.6</b>	<b>156.2</b>
<b>300AS2*</b>	<b>63.0</b>	<b>156.6</b>
<b>300BS</b>	<b>32.0</b>	<b>105.1</b>
<b>300BD</b>	<b>25.0</b>	<b>57.0</b>
<b>300CS</b>	<b>26.1</b>	<b>78.1</b>
<b>300CD</b>	<b>20.3</b>	<b>51.2</b>
<b>EM(eddy)</b>	<b>68.2</b>	<b>201.3</b>
<b>HM(river)</b>	<b>66.9</b>	<b>200.1</b>

## Field Measurements

**Beach:** 194L

**Date:** January 13,14, and 15, 1994

**Notes:**

Sample	Temp.	Sp cond.	pH	[H+]	DO(ml)	NH4mv	NH4+
aways average	13.1	1301	7.7	2.20E-08	1.3	96.9	0.5
aways std. dev.	1.57	413	0.24	8.93E-09	0.6	19.6	0.3
middles average	14.5	1078	7.9	1.73E-08	1.9	120.7	0.2
middles std. dev.	1.69	410	0.24	8.25E-09	0.6	17.8	0.2
close average	14.5	990	7.8	1.54E-08	2.1	133.0	0.1
close std. dev.	2.25	401	0.23	6.97E-09	0.7	18.0	0.2
Avg. surface water	10.3	1345	7.7	1.88E-08	1.4	123.9	0.1
Std.dev.	4.38	90	0.12	5.13E-09	0.6	10.0	0.1
50AD	14	1841	7.42	3.80E-08	0.6	77.7	1.06
100AS	12.4	1180	7.67	2.14E-08	1.9	96	0.45
100AD	13.1	841	7.78	1.66E-08	2.1	100.2	0.37
100BS	12.3	1946	7.46	3.47E-08	2.3	128	0.10
100BD	14.8	1333	7.7	2.00E-08	1.6	96	0.45
100CS	12.2	1284	7.74	1.82E-08	2.3	139	0.06
100CD	14.1	1400	7.82	1.51E-08	2.2	119	0.16
200AS*	10.4	1502	7.5	3.16E-08	1.3	93.9	0.50
200AD	13.9	1794	7.87	1.35E-08	1.1	97.7	0.42
200BS	13.3	1150	7.64	2.29E-08	2.7	131	0.09
200BD	13.8	943	7.86	1.38E-08	2	101	0.36
200CS	12.1	906	7.65	2.24E-08	2.3	142	0.05
200CD	13.9	1289	7.91	1.23E-08	1.7	121	0.14
300AS1*	14.4	1006	7.78	1.66E-08	0.4	114	0.20
300AS2*	13.2	943	7.78	1.66E-08	1.4	99	0.39
300BS	15.6	570	8.07	8.51E-09	1	125	0.12
300BD	17.4	524	8.42	3.80E-09	2	143	0.05
300BD dup	NA	NA	NA	NA	NA	NA	NA
300CS	15	557	7.79	1.62E-08	2.6	137	0.07
300CD	19.5	504	8.1	7.94E-09	1.7	140	0.06
100CS-2	7.2	1281	7.65	2.24E-08	1.8	131	0.09
100CD-2	13.4	1408	7.82	1.51E-08	1	116.8	0.17
200CS-2	13.9	948	7.67	2.14E-08	2.2	135	0.07
200CD-2	11.7	1280	7.94	1.15E-08	1.8	123.4	0.13
300CS-2	11.1	572	7.79	1.62E-08	3.8	128	0.10
300CD-2	18.9	508	8.04	9.12E-09	2	130	0.09
EM	9.3	867	8.45	3.55E-09	10.3	136	0.07
HM	9.5	866	8.45	3.55E-09	10.2	138	0.06

### Lab Analysis

<b>Beach:</b>	194L					
<b>Date:</b>	January 13,14, and 15, 1994					
<b>Notes:</b>						
<b>Sample</b>	[K] ppm	[Na] ppm	[Ca] ppm	[Mg] ppm	[Cl] ppm	[SO4] ppm
aways average	-0.5	75.6	187.3	43.0	73.6	179.4
aways std. dev.	1.2	34.8	72.8	15.1	38.3	117.6
middles average	-0.4	62.8	181.5	38.2	66.3	179.1
middles std. dev.	1.2	36.8	73.1	13.4	39.8	117.0
close average	-0.5	63.2	152.3	32.9	53.7	211.8
close std. dev.	1.1	40.9	64.2	10.6	32.0	125.3
Avg. surface water	-0.9	59.9	155.4	34.5	81.8	350.0
Std.dev.	0.1	0.1	22.9	5.5	1.9	30.4
50AD	1.5	110.0	297.3	73.9	114.6	37.6
100AS	0.1	91.6	202.9	44.9	54.5	134.8
100AD	-0.3	56.4	142.2	34.4	45.5	146.9
100BS	0.2	128.3	324.0	65.5	169.1	378.4
100BD	1.5	76.8	239.0	49.3	78.1	163.6
100CS	-0.1	95.5	194.7	39.4	83.2	455.1
100CD	0.6	89.7	240.3	50.9	81.1	259.7
200AS*	-0.4	108.4	238.4	50.7	95.1	282.1
200AD					112.2	339.4
200BS	-0.6	94.2	209.6	38.8	70.5	263.4
200BD	0.7	55.9	168.5	31.5	45.1	167.6
200CS	-0.6	79.9	133.6	26.1	42.7	176.3
200CD	0.3	102.9	189.4	39.1	79.0	278.0
300AS1*	-1.9	44.8	124.6	26.7	46.9	171.3
300AS2*	-2.1	42.4	118.2	27.8	46.7	143.4
300BS	-2.1	15.6	80.0	20.1	17.2	53.1
300BD	-2.2	6.2	67.8	23.7	18.0	48.2
300BD dup	-1.8	4.7	67.6	23.7	18.0	47.9
300CS	-1.9	6.9	90.3	18.8	17.9	55.9
300CD	-1.3	4.1	65.3	23.3	18.6	46.0
100CS-2	-1.0	59.9	139.3	30.6	83.2	328.6
100CD-2	-0.9	60.0	171.6	38.4	80.5	371.5
200CS-2	-1.5	52.7	89.8	19.4	41.4	163.8
200CD-2	-0.7	68.3	132.8	29.9	79.9	280.2
300CS-2	-1.6	8.7	88.9	18.4	19.0	54.6
300CD-2	-1.3	8.3	65.2	23.5	22.3	47.1
EM	-0.1	65.1	129.1	24.1	53.3	202.2
HM	0.4	69.3	127.2	24.4	52.9	200.3